A NUMERICAL IMPLEMENTATION OF LANDSCAPE EVOLUTION MODELS

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In this communication our goal is to propose a simple and efficient numerical solution for the solution of a system of three partial differential equations arising in the modeling of landscape evolution. Indeed, as remarked by several authors, the main physical laws that have been proposed in landscape evolution models (LEMs) can be converted into a minimal system of three partial differential equations. The first one is a transport equation that governs the water run-off. It is the simplest interpretation of Saint-Venant shallow water equations. A second equation, of Hamilton-Jacobi type with a dissipative term, governs the terrain evolution by detachment-limited erosion, creep and sedimentation. A third equation is necessary to describe the sediment transport in water. This equation governs the transport of the suspended sediment load in water. The challenge that we address is to simulate in reasonable time such a system of equations on a large enough digital elevation model, generally acquired by satellite or aerial imaging. We compare our proposed solution with existing implementations and explain how each equation can be reformulated as a discrete scheme on a raster, that is still conservative as the continuous equations. Furthermore we show that the systematic introduction of a multiscale procedure leads to extremely fast simulations. This permits to simulate water run-off on fixed landscapes, and to explore and compare in reasonable time several models and their parameters. Last but not least, we address the problem of an efficient visualisation of a three phases results : the elevation, the water height and the sediment load.
Fig. 1 shows a typical result for the Island "La Réunion" with 15% lands off.

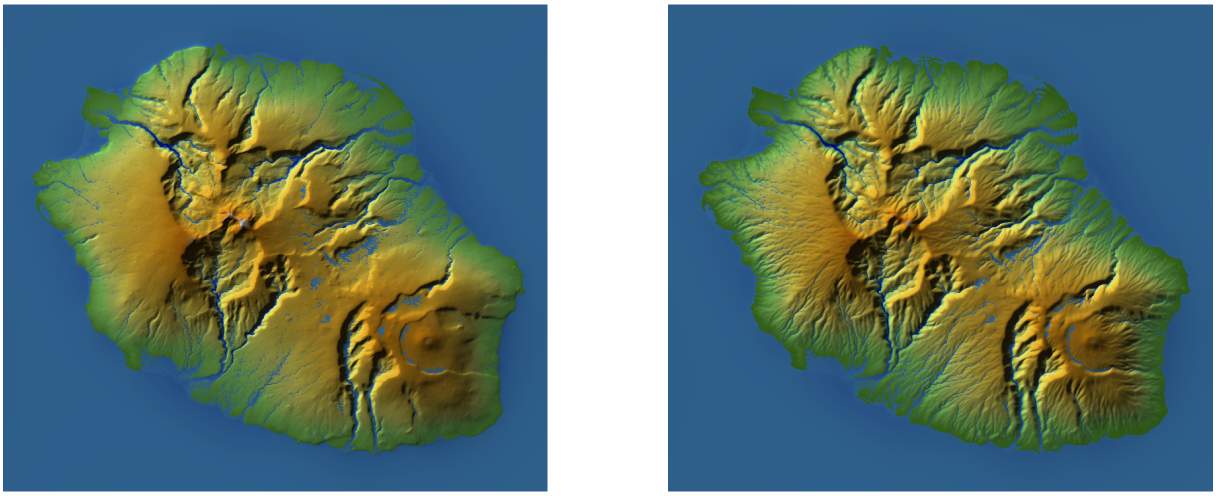

Figure 1. Simulated evolution of "La Réunion", emergence of the fine river network.

A demo (usr:demo, pwd:demo) can be tested on line at the adress

`http://dev.ipol.im/~ibal/ipol_demo/LEM/`

References

[1] A. Chen, J. Darbon, J.M. Morel, *Landscape evolution models: A review of their fundamental equations*, Geomorphology **219**, 68–86 (2014).

[2] T.J. Coulthard, J.C. Neal, P.D. Bates, J. Ramirez, G.A. Almeida, G.R. Hancock, *Integrating the LISFLOOD-FP 2D hydrodynamic model with the CAESAR model: implications for modelling landscape evolution*, Earth Surface Processes and Landforms **38(15)**, 1897–1906 (2013)

[3] T.J. Coulthard, *Landscape evolution models: a software review.*, Hydrological processes **15(1)**, 165–173 (2001)